- *Dynamic Yield Models based on Irish research data and internationally accepted forest modelling principles have been produced for a number of Irish forest tree species.*
- *The models are used in predicting the current and future production of timber from forests based on their current state and future management intentions.*
- *The models have been integrated by Coillte into its forest inventory and production forecasting system.*
- *The models are available to the private forestry sector through a user interface called GROWFOR, available from and supported by Forest Sector Development Division of the Department of Agriculture, Food and the Marine.*

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Dynamic yield models used in Irish forestry

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Introduction

Dynamic yield models based on Irish research data and internationally accepted forest modelling principles have been produced for a number of Irish forest tree species. These models facilitate bespoke forest management planning and practice. The models are available to and used by the private forestry sector using a user friendly computer interface called GROWFOR. The models are also integrated into Coillte's inventory and timber production forecasting system.

The purpose of this document is to explain what dynamic yield models are, how they were developed in Ireland and why they are so useful in forecasting future timber production.

What are Dynamic Yield Models?

Yield models are used in predicting the future production of timber from forests based on a certain set of circumstances. Dynamic yield models are interactive and facilitate users such as foresters in analysing the potential outcome of different forest management scenarios. For example, a forester may wish to model what the effect of thinning would be every four years compared to every five years. This can be achieved using dynamic yield models.

Why use Dynamic Yield Models?

It is an essential part of forest management to be able to forecast the future timber volumes and products that will be produced from forests. This is important in both operational and financial planning for all forest owners. For example, models might be used in deciding when a forest road should be built or whether a particular forest for sale is a suitable investment for a pension requirement in twenty years time.

Until recently, forest growth and yield modelling in Ireland was carried out using Forestry Commission Yield Models for Forest Management (Forestry Commission 1981 Booklet 48). In the absence of Irish models, these models served the Irish forestry sector well. However, since 1999, the Irish forest industry,

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with support from COFORD and Coillte, has led a project to develop dynamic yield models which are based on Irish research data and which offer greater flexibility in terms of both inputs and outputs. More specifically, dynamic yield models use actual collected inventory data as input and generate output based on user defined forest management regimes. By contrast, when using Forestry Commission Yield Models, users have to fit their own data to the nearest equivalent model and once a model is selected the user can be locked into a pre-determined management system. The greater flexibility offered by dynamic yield models is of huge significance to foresters and forest owners who can now model the potential effect of managing their forests in different ways.

How do the models work?

In order for the Irish dynamic yield models to work, forest inventory data are required in the form of species, age, top height (m), stocking (stems/ha) and either basal area (m^2/ha) or mean diameter at breast height (cm). These data are input into the model and a current standing volume per hectare and associated product assortments are generated. The forest can then be 'grown on' to a future age at which the user may decide to thin or to fell the stand.

When faced with a thinning decision, the user can specify thinning intensity in terms of the number of stems, the volume of timber or the basal area to be removed per hectare.

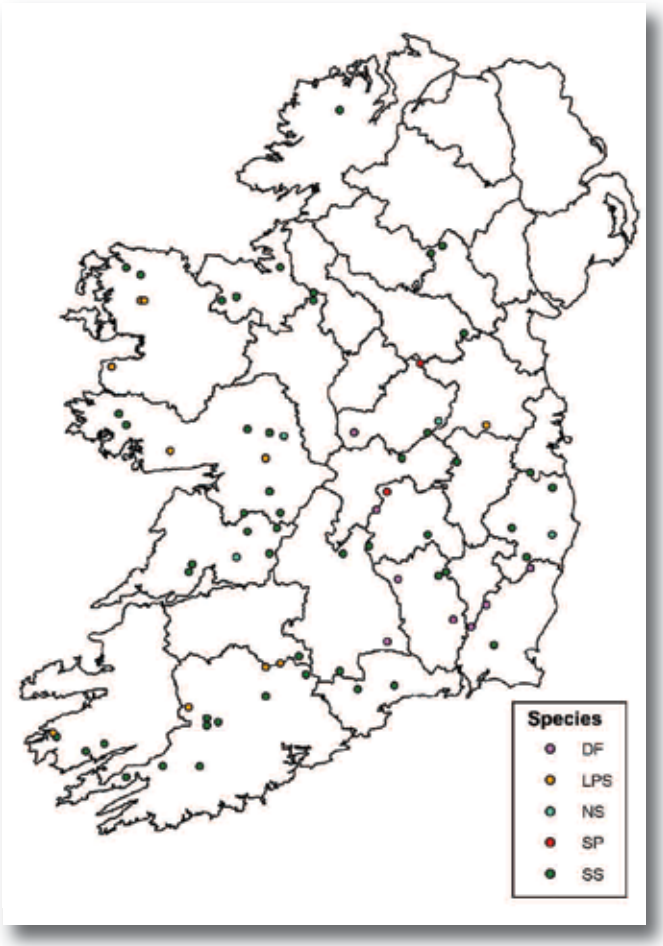
Following each thinning the stand can be 'grown on' again to another future age and the process repeated until a decision is made to finally fell the stand. At all stages, the timing, frequency and intensity of thinning interventions are under the user's control.

For each year, the model provides projections of stand conditions in terms of age, top height (m), stems per hectare, mean diameter at breast height (cm), basal area (m^2/ha), mean volume per stem (m^3), volume per hectare (m^3/ha). For years in which thinning has been specified, the same information is provided for the stand prior to and post thinning operations and for the thinning itself.

How were the models developed?

Most of the data used in the development of the Irish dynamic yield models were collected from forest research plots established throughout the country for various purposes over a period spanning from the 1950s to the present. Most of these plots were located in Coillte managed forests and some are still actively managed as such today.

The development process for the dynamic models began in 2001 with the commencement of the DYNAMICYIELD project which was jointly funded by COFORD and Coillte. The project objective was to develop an alternative growth projection mechanism for Irish grown conifers amenable to simulating a wide range of management alternatives specific to Irish conditions. A modelling specialist was engaged by the project and the first draft model for Sitka spruce was produced in 2003.



Location of sample plots on which dynamic models for Sitka spruce, lodgepole pine, Norway spruce, Douglas fir and Scots pine are based.

The development of stand-level, dynamic growth models proceeded by adopting a modelling methodology where a small number of stand variables were chosen to represent the stand. Future states of the stand can then be determined from the current state, provided any future actions such as thinnings are detailed. The stand variables chosen are top height, basal area and stocking (stems per hectare), reliable estimates of which must be available before the models can be utilised. Forecasted or projected estimates of top height, basal area and stems are generated by the models using very complex mathematical functions drawn up with the aid of data measured in the forest research plots.

Following a rigorous validation and testing procedure (as detailed below), the Sitka spruce models for thinned and unthinned stands and user interface (GROWFOR) were officially launched at a series of workshops held during 2005. Additional models for four other species (Norway spruce, lodgepole pine, Douglas fir and Scots pine) have been launched in the meantime following similar development and testing.

Testing of the models

In 2003, a validation study was conducted by Coillte on the draft Sitka spruce model to compare volume estimates produced by the draft model (which had been produced using many years of results from research plots) with actual volumes measured in 'non research' Sitka spruce stands in Coillte's estate. The study was conducted in 23 locations chosen across the range of yield classes in the estate. Data were gathered from 114 plots.

The study revealed that the dynamic model, based on research plots alone overestimated current measured volume in Sitka spruce by an average of 8%. Following further analysis of the research and the 'non-research' plot distribution, it was concluded that the reason for the 8% bias could be explained by the non-representative spread of the research plots which tended, in the main, to be located in high Yield Class stands.

On discovery of this bias in the Sitka spruce model, the program which calculates volume was revised, tested and retested until the bias was reduced to less than 1%. This was done by incorporating the newly collected data from 'non research' stands into the overall dataset. The revision of the volume program also meant that assortment volume estimates achieved an equally high level of accuracy.

Measurement of a volume sample tree (Japanese larch).

With the aid of COFORD funding calibration studies were also conducted on the Norway spruce, lodgepole pine, Douglas fir and Scots pine models in a similar fashion. In these exercises, various levels of bias were uncovered and subsequently corrected.

How accurate are the models?

The accuracy of output from any mathematical model is dependent to a large extent on the quality of inputted data. Dynamic yield models are no different in this regard and it is important that quality inventory data are used as input into the model.

The forest research plots, upon which the models are largely based, did not contain any early growth information and very limited growth information for very old or large dimensioned trees. Therefore, the models are best confined for use from ages 10 to 60 up until clearfelling. Similarly, the forest research plots did not provide information outside of certain ranges and therefore the models are most reliable and should only be operated within the ranges 100 to 5,000 stems/ha, basal areas of 10 to 100 m^2/ha and with a minimum top height of 5 m.

When Irish dynamic yield models are compared directly with British Forestry Commission (BFC) yield models the following observations have been noted:

- Current volumes (i.e. where there is no growth projection) produced by Irish dynamic yield models are frequently greater. This may be attributable to a combination of factors including:
  - Irish stands show improved upper stem diameters due to improved growing stock and/or growth conditions;
  - BFC volume-estimates may have been prepared on a conservative basis due to mensurational techniques employed;
- Growth projections to mid-rotation using Irish dynamic yield models indicate increased basal area growth and diminished mortality. This effect can be reversed in late rotation.
- Unthinned stands in Ireland are characterised by a slower rate of mortality and often by a higher rate of basal area growth.
- Irish dynamic yield models allow for mortality between thinnings, unlike BFC thinned models.

Available models

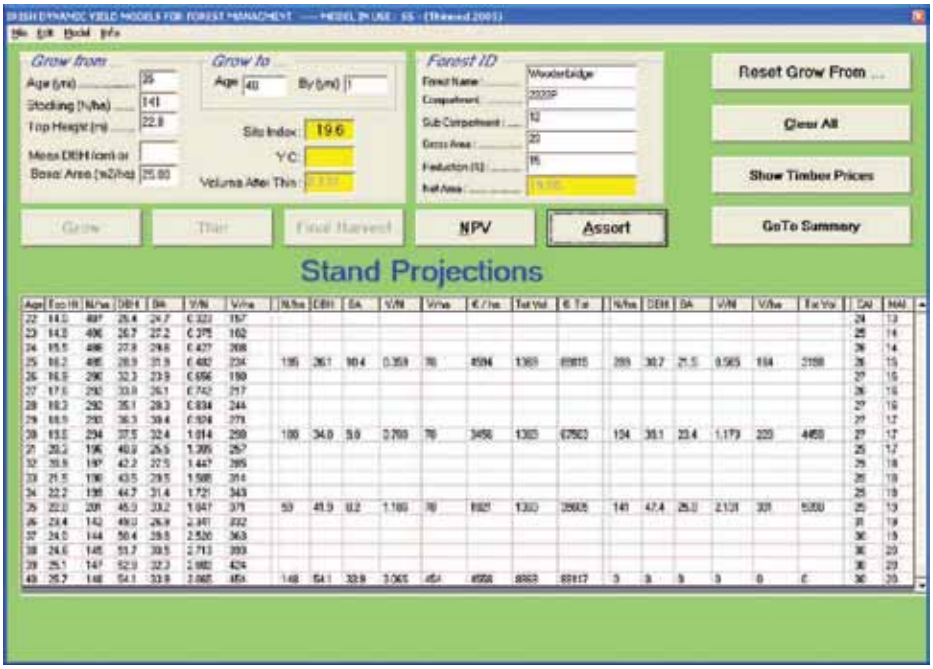
To date, dynamic models for thinned and unthinned stands of Sitka spruce, Norway spruce, lodgepole pine (coastal), Douglas fir and Scots pine have been produced. Models for Japanese larch and ash are currently in production as part of the COFORD-funded STANDMODEL project.

Accessing the Dynamic Yield Models

Coillte has integrated the new dynamic models into its forest inventory and production forecasting system. For the private forestry sector, COFORD has funded the development of a PC-based user-friendly interface called GROWFOR (see below) which allows users access to utilise the full functionality of the models.

GROWFOR

GROWFOR is the name of the software package that provides a user interface for the Irish dynamic yield models. In addition to facilitating interactive modelling of different forest management scenarios, GROWFOR has some additional functionality such as a forest valuation tool and the option to define different timber product assortments. A software licence for the use of GROWFOR can be obtained from Forest Sector Development Division, Department of Agriculture, Food and the Marine (DAFM) following participation in an official GROWFOR training course which DAFM provides from time to time depending on demand. DAFM also funds a helpline for queries relating to dynamic yield models and GROWFOR which is growfor@coford.ie.



A screenshot from GROWFOR.